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Optimization of DPOAE fine structure measurements

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1. Objectives

For current and future experiments at the Department of Acoustics of Aalborg University, it is desired to monitor possible changes in the distortion product otoacoustic emissions (DPOAEs) of human subjects after sound exposures, in particular changes in the fine structures. The method previously used (using the commercial system ILO96 from Otodynamics), has covered frequencies from 1 kHz to 6 kHz, with an averaging time of 2.6 seconds for each primary presented (f_1 and f_2). This leads to a total measuring time of approximately 30 minutes ([1],[2] and [3]). Measurements performed in this way are impractical for the correct assessment of sound exposure effects, as changes within the cochlea may occur much faster.

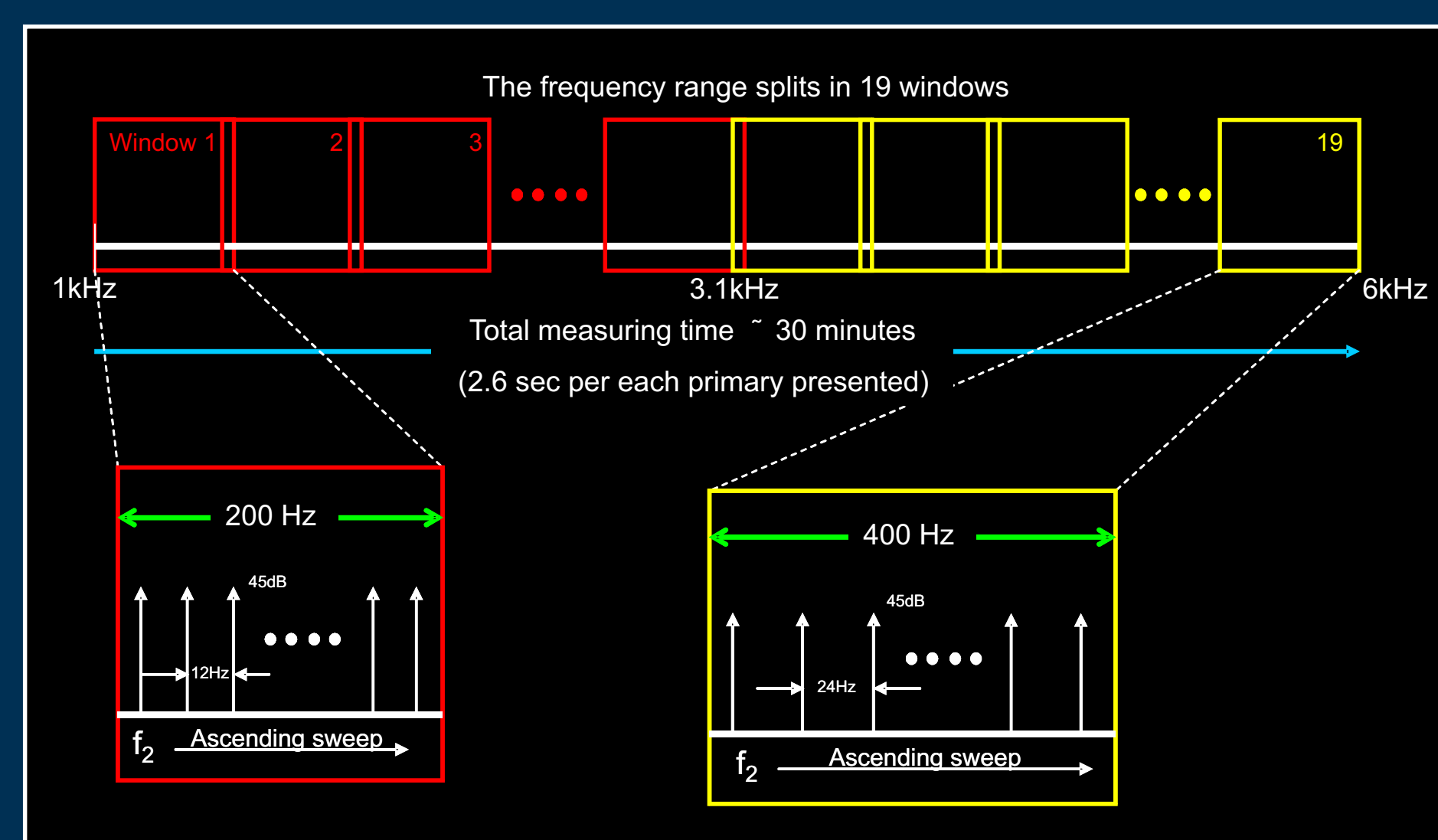
An experiment was conducted to develop a faster, but still reliable, DPOAE measuring method by changing (1) the averaging time in the presentation of the primaries and (2) methodology of the ILO96.

2. Methods

Two different ILO96 setups were compared: DPOAE30 and DPOAE5.

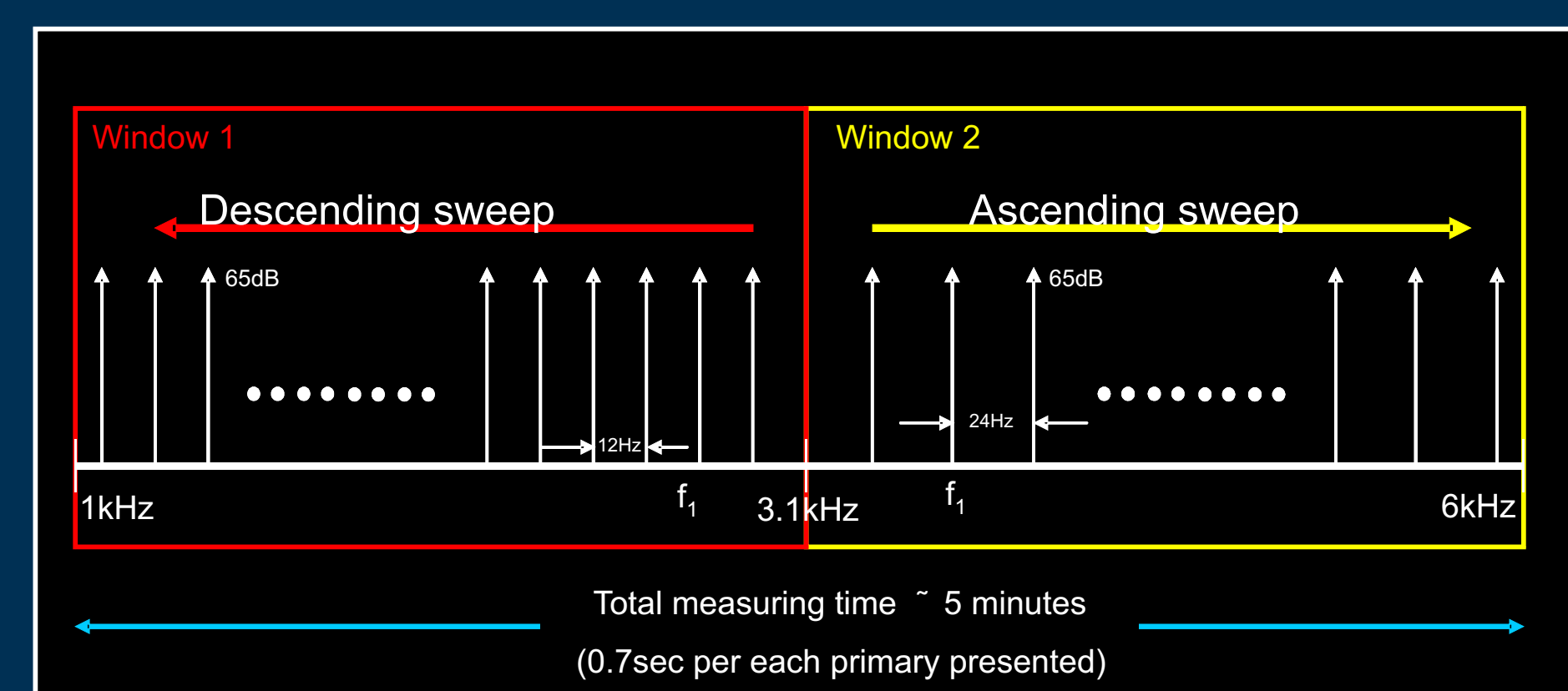
Both setups perform DPOAE fine structure measurements from 1 kHz to 6 kHz with $L1/L2=65/45$ dB and $f_2/f_1=1.22$.

DPOAE30



- System checks: Probe fitting and primary levels $L1/L2$ at $f_1=1636$ Hz and $f_2=2002$ Hz.

DPOAE5

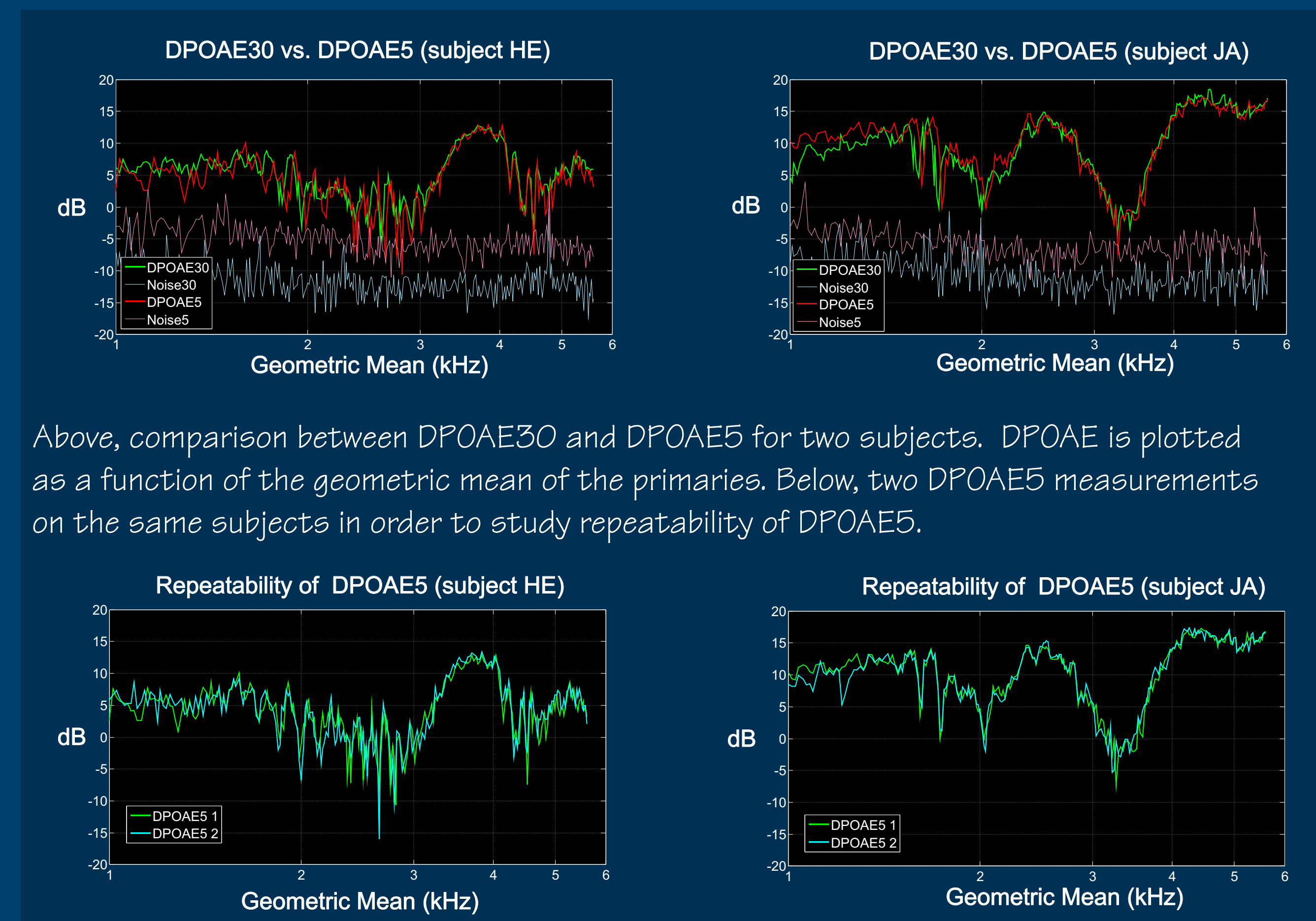
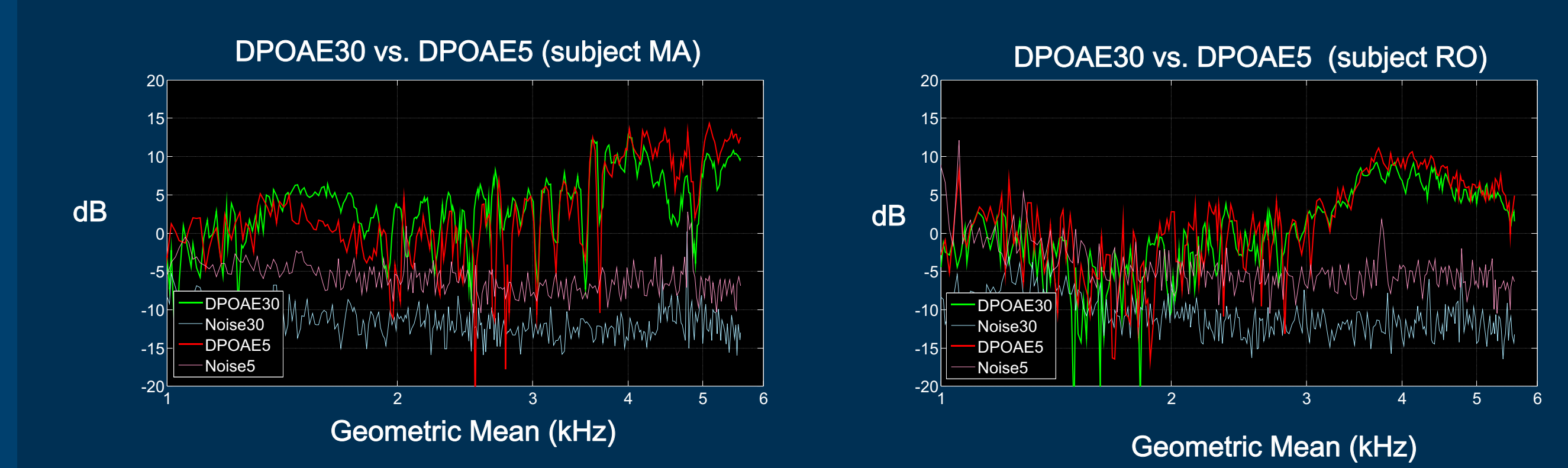


- System checks: Probe fitting and primary levels $L1/L2$ at $f_1=2551$ Hz and $f_2=3125$ Hz for both windows.

Subjects

6 subjects (3 male, 3 female) participated in the experiment. All subjects had pure-tone hearing levels below 20 dB HL and normal middle-ear functions. For each subject the session consisted on one measurement of DPOAE according to setup DPOAE30 and two measurements according to setup DPOAE5 in a balanced order. Measurements were done only in the right ear and without refitting the probe. Subjects were seated in a double-walled, sound-isolated audiometry chamber at the Department of Acoustics of Aalborg University.

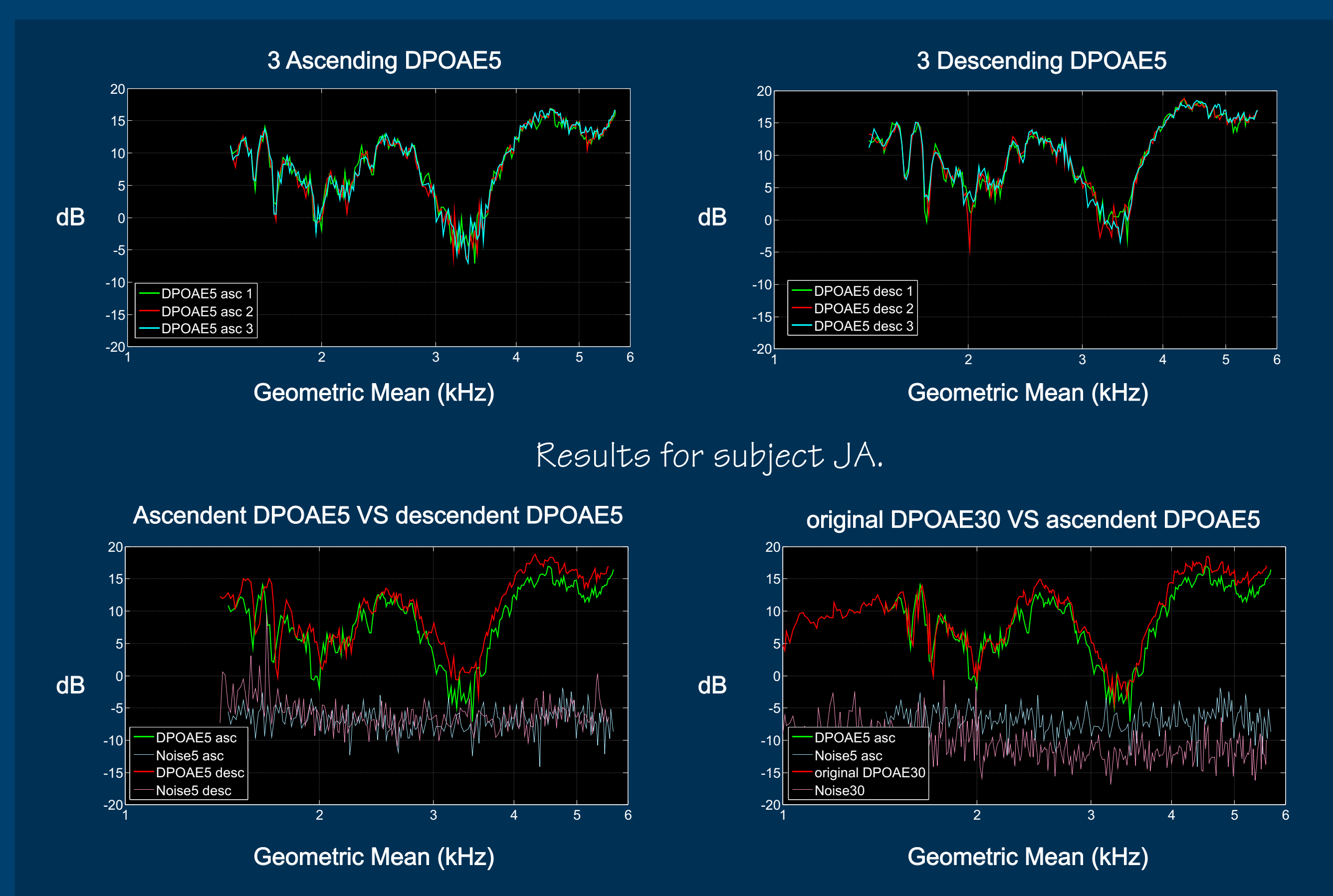
3. Results



Above, comparison between DPOAE30 and DPOAE5 for two subjects. DPOAE is plotted as a function of the geometric mean of the primaries. Below, two DPOAE5 measurements on the same subjects in order to study repeatability of DPOAE5.

Influence of the sweeping direction

It was observed that the DPOAE results are slightly shifted below 3 kHz when comparing DPOAE30 vs DPOAE5. Additional measurements were made in order to check if this difference could be due to the different sweeping direction of the primaries (ascending for DPOAE30 and descending for DPOAE5). 6 consecutive DPOAE5 measurements without refitting the probe were made. For 3 of the measurements the primaries were presented in ascending order from 1.6 kHz to 6.2 kHz, while for the other 3, the primaries were presented in descending order (from 6.2 kHz to 1.6 kHz).



4. Conclusions

- **Background Noise:** As expected, DPOAE30 measurements have a better S/N due to the longer averaging time during the presentation of the primaries.
- **Similarities between DPOAE30 and DPOAE5:** There is a good agreement between DPOAE30 and DPOAE5 for subjects with a good S/N. A low S/N can lead to higher fluctuations for DPOAE5 measurements.
- **Setup DPOAE5 is able to detect fine structures**
- **DPOAE5 measurements are highly repeatable**
- **Influence of the sweeping direction:** The sweeping order (either ascending or descending) during the presentation of the primaries has an effect both in level and frequency. This effect is more clearly seen when detecting fine structures, as they appear slightly shifted in frequency.

Acknowledgements

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References

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- [2] Reuter and Hammershøi (2005), Proc. Inter-Noise 2005, Rio de Janeiro, paper 1962 (7 pages).
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